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MEASUREMENT OF PRESSURE IN TURBOMACHINE IMPELLERS AT HIGH ROTATIONAL VELOCITIES

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16. Abstract

The present work discusses briefly some considerations for realizing effective hydrodynamic sealing of turbine shafts in order to permit pressure measurements, with the aid of either mechanical or electrical pressure sensors, at very high revolutions per minute. The use of a water jacket for cooling the sensors is discussed.

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MEASUREMENT OF PRESSURE IN TRUBOMACHINE IMPELLERS AT HIGH ROTATIONAL VELOCITIES

I. M. Korshin

In study of flow in the turbine blading, the most difficult task is measurement of pressure and velocity in the impeller channels, especially at high rotational velcoties. /17*

In existing mechanical pressure sensors with contact seals, the rotational velocity is limited by the mechanical strength of the seal part and the frictional heat given off. In this case, possible leaks decrease the accuracy of measurement.

The use of electrical pressure sensors involves creation of current take-off devices, operating reliably without interference, the service life of which until overhaul is a few hours.

In this case, the rotational velocity is limited by the strength and reliability of operation of the pressure sensor, located in a centrifugal force field.

At high shaft rotational velocities ($n > 10,000$ rpm), the use of a non-contact seal is advisable. Such a seal can be made, in particular, in the form of a hydrodynamic seal [1]. The use of a spiral groove seal, with the opposite seals filled with a grease, which is resistant to elevated temperatures, is effective. Pressure sensors with such a seal have been described in work [2].

Recently, a hydrodynamic seal has been used for sealing turbomachine shafts. The sealing effect is created by a liquid, supplied to the cavities formed by multiple spiral grooves. The principle

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*Numbers in the margin indicate pagination in the foreign text.

of operation of this seal has been described in works [3, 4]. This seal ensures practically complete tightness at pressures below the critical pressure, when loss of stability of operation of the seal sets in.

A diagram of a hydrodynamic seal is shown in Fig. 1. /18

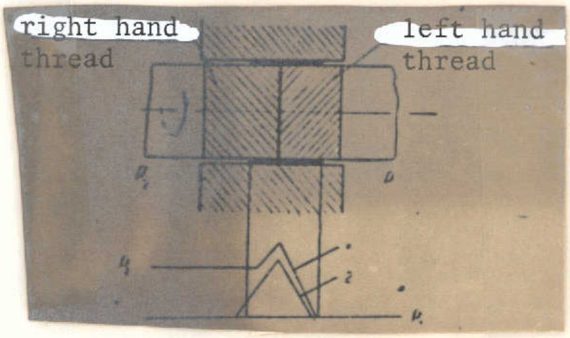

Fig. 1

Experimental studies were made of a hydrodynamic seal, at n ≤ 16,000 rpm, with various groove shapes and spacing and with different numbers of threads. They were made by the author, together with V. A. Tikhonov, at the SKBK.[1] The study showed that a seal, in which sealing grooves were made in the fixed housing and the shaft surface was made smooth, gave the best results, as to stability and efficiency of operation. The optimum groove shape and size depend on the type of sealing liquid.

The tests showed that it is most advisable to use water as the sealing liquid, although it produces a somewhat lesser sealing effect than lubricating oil or glycerin. The use of the latter may /19 lead to an abrupt change in the sealing effect with change in temperature conditions.

A cooling jacket must be incorporated in all cases, for temperature stabilization. The optimum radial clearance between the seal housing and shaft is between 0.1 and 0.25. Although the sealing effect increases sharply with decrease in clearance, in this case, with inexact fabrication, there is the possibility of the shaft touching the seal housing, heating and sticking of it. A

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[1] [SKBK -- Special Design Office K]

2-channel pressure sensor, for measurement of pressure and velocity in the rotating channels, developed on the basis of a hydrodynamic seal, is shown in Fig. 2.

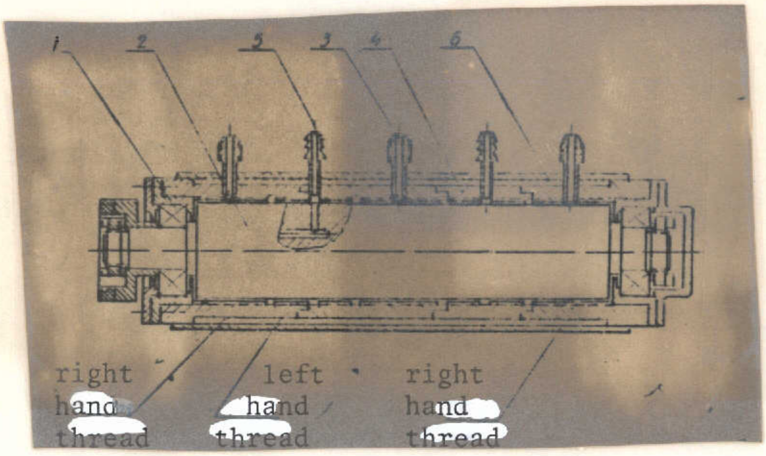

Fig. 2

Sensor shaft 2 is smooth, made of steel, and it rotates in ball bearings 1, filled with lubricating grease. Sensor housing 4 is made of sectional bronze bushings, which are brazed together. This is done, to make it possible to make 2-directional (left and right) threads on each bushing. Connecting pipe 5 is used to take off pressure from the shaft to the manometers. Connecting pipe 3 is used to supply sealing liquid. It is advisable to supply the liquid from a small container, installed at a height of 3-4 m.

There is a water jacket to cool the pressure sensor. It is formed by the housing, with cylinder 6 soldered to it, through which the cooling water circulates. Cylinder 6 has a horizontal joint, to ensure the possibility of installation on the housing, after welding the connecting pipes to the housing.

The permissible rotational velocity of the sensor shaft is limited by the performance capacity of the shaft bearings. The

sealing capacity of the hydrodynamic seal increases with increase /20
in rotational velocity.

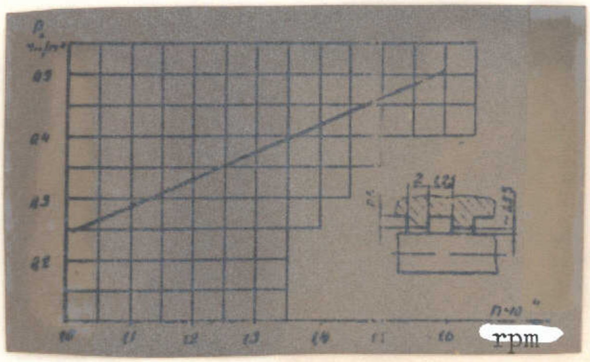

Fig. 3

A graph of the permissible pressure vs. rotational velocity, while operating with water, is shown in Fig. 3. The shape of the threads is indicated in Fig. 3. The thread pitch is 80 mm and the number of turns is 25. As is evident, there is an almost linear dependence of pressure permitted on shaft rotation speed in this case.

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